



April 10, 2017

**BY ELECTRONIC FILING**

Marlene H. Dortch  
Secretary  
Federal Communications Commission  
445 12<sup>th</sup> Street, S.W.  
Washington, DC 20554

Re: *Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al.*, GN  
Docket No. 14-177, IB Docket Nos. 15-256 and 97-95; RM-11664; and WT  
Docket No. 10-112

Dear Ms. Dortch:

Throughout this proceeding, EchoStar Satellite Operating Corporation and Hughes Network Systems, LLC (collectively “EchoStar”) have argued that the Commission should adopt rules that enable all spectrum users, including satellite systems, to thrive and make productive use of the bands above 24 GHz to provide broadband services to all Americans. Accordingly, the Commission must adopt a technology neutral regime whereby all platforms can compete and participate in the 5G ecosystem.

Satellites have played an important role in the nation’s broadband evolution over the last three decades, advancing from narrowband services in the 1980’s to full-fledged broadband services today. Satellite operators are continuing to invest in advanced technologies to increase the spectral efficiency of their systems so that they can continue to be at the forefront of providing broadband to commercial, enterprise, and individual customers no matter where they are located in the U.S., including in areas underserved or completely unserved by terrestrial alternatives. However, like terrestrial networks, technological innovation only goes so far. Satellite networks need access to additional spectrum to meet important customer demands.

In order to understand the need for ensuring that satellites have the resources they need going forward, it is important to appreciate their historical and ongoing role in the nation’s broadband ecosystem. Accordingly, the attached white paper chronicles the evolution of the technology, capacity, and use of the Hughes satellite system. EchoStar believes that this paper will provide important additional context as the Commission considers how best to craft its spectrum regime for the bands above 24 GHz to ensure that the result is a technology neutral regulatory regime that enables competition between all platforms.

Respectfully submitted,

*/s/ Jennifer A. Manner*

Jennifer A. Manner

Attachment

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## **WHITE PAPER:**

# **Evolution of Hughes Network Systems LLC's Broadband Satellite Services From Narrowband to Federal Communications Commission -Defined Broadband Speeds<sup>1</sup>**

**April 2017**

## **Introduction**

Since the 1980's, satellite operators have been on the leading edge of providing data service globally. As demand for data services increased and customers required more capacity at greater speed, the satellite industry (like terrestrial providers) developed and deployed improved broadband technology. For over three decades, Hughes Networks Systems LLC (Hughes), a U.S. based company and the leading global provider of broadband services,<sup>2</sup> has been at the forefront of this effort, providing satellite-based high-speed broadband services to U.S. consumers, including commercial and government customers. What started as a service supporting narrowband data for tens of thousands of customers has grown into a network of three U.S. satellites specifically designed to meet the growing consumer need for broadband satellite services. Today, Hughes serves more than a million broadband subscribers, many in the most rural and remote parts of the United States. Thanks to Hughes and its competitors, U.S. customers have access to cost-effective high-speed broadband services across the country, even in rural and remote areas. To achieve this success, Hughes alone has invested billions of dollars—and it knows that continued success will require continued investment and innovation.

This paper examines the evolution of the technology, capacity, and use of the Hughes satellite network to serve its broadband customers. This evolution began with the use of leased capacity on general purpose Ku-band satellites that could support customers' basic data needs, and progressed through three generations of purpose-built, high-throughput broadband satellites to reach the point where users, across the United States, even in rural and remote areas, have access to broadband at speeds of 25/3 Mbps or more utilizing the Ka Band (18/28 GHz). Underlying this evolution are dramatic improvements in satellite technology and more efficient use of the spectrum resource. In less than a decade, Hughes has improved the efficiency of its satellites exponentially, achieving two orders of magnitude greater throughput in order to meet the bandwidth requirements of its network's users.

Hughes is continuously working to improve throughput and speed of its network in its next generations of broadband satellites to satisfy consumers' demands. As discussed herein, in order to do this, Hughes will need access to significantly more bandwidth (spectrum), largely in the Q and V bands (35-55 GHz) as well as continued access to the bands it operates today. This will ensure that satellite broadband remains an important competitive platform to deliver advanced broadband services, such as 5G, to U.S. consumers.

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<sup>1</sup> The authors are Jennifer A. Manner, Senior Vice President, Regulatory Affairs and Brennan Price, Senior Principal Engineer, Regulatory Affairs at Hughes Network Systems, LLC.

<sup>2</sup> Hughes is the largest provider of broadband satellite services in North America, serving over one million broadband subscribers as of December 31, 2016. Hughes has over 1,500 U.S. employees.



## **Demands for Higher Speeds and More Capacity Led to the Development of SPACEWAY® 3**

Initially, Hughes and other fixed satellite service operators were able to meet the demands of consumers by providing access to leased satellite services using the Ku-band (12/14 GHz) spectrum. However, these Hughes data offerings in the mid-2000s had limited capacity as did terrestrial offerings. The HughesNet® HN7000S platform utilized compression and modulation technology available at that time (early versions of the DVB-S2 standard) to offer aggregate capacity of 1 Gbps. As late as 2007, the highest speed offered by a Hughes service plan was 1 Mbps. While that seems slow by today's standards, at the time it was well in excess of the 200 kbps standard used by the Federal Communications Commission (FCC) to define broadband services through 2008.<sup>3</sup>



*Figure 1. HughesNet Prebroadband User Equipment*

Hughes recognized the trend at that time for higher speeds and greater capacity. In order to meet market demand, it designed and constructed its first broadband satellite, SPACEWAY 3. This satellite operates in the Ka band, in which one gigahertz of spectrum is available to support satellite operations with properties that facilitate smaller spot beams and greater frequency reuse. Hughes increased its development of such spectrum management techniques to ensure that SPACEWAY 3 would help to address the anticipated increased customer demand for broadband services.

## **SPACEWAY 3: True Broadband Is a Reality for the First Time in Rural and Remote Parts of the Country**



*Figure 2. SPACEWAY 3*

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<sup>3</sup> See *Fifth Broadband Deployment Report*, 23 FCC Rcd. 9615, ¶ 2 (2008).



Hughes launched SPACEWAY 3 in 2007, and in 2008 it began to provide broadband service to consumers throughout North America. Subscription quickly took off as customers came to appreciate the improved capabilities this satellite offered. Hughes initially offered services of up to 2 Mbps download speeds in 2008 and enhanced the offering to 5 Mbps in 2013. In 2008, less than half of all broadband services in the U.S. had speeds of 3 Mbps or more, and only 34 percent had speeds of 6 Mbps or more.<sup>4</sup> Thus, Hughes offered a competitive service which compares favorably to the customer experience of many wireline DSL customers even today.<sup>5</sup>

SPACEWAY 3 also achieved a much higher throughput than prior generation satellites by using a dynamic mesh spot beam downlink network employing the RSM-A standard.<sup>6</sup> The mesh spot beam network allows for higher throughput by reusing frequencies many times across the country in different satellite beams aimed at different locations. The satellite, which remains in service, has an overall capacity of 10 Gbps, an increase in capacity of nearly 80 times over the pre-broadband generation.

However, like the previous generation, Hughes knew that consumers' demands for higher capacity and speeds needed to be addressed, and it began designing and constructing its next generation satellite, JUPITER 1.

## JUPITER 1

In 2012, Hughes launched its JUPITER 1 satellite which used advanced technology to deliver broadband speeds of up to 15/3 Mbps for the first time to consumers throughout the country, no matter where they were located. Here again, Hughes provided a level of service that greatly surpassed the Commission's definition of broadband at the time (4/1 Mbps).<sup>7</sup> In the first year of JUPITER 1 operation alone, Hughes saw a 33% increase in its customer base.

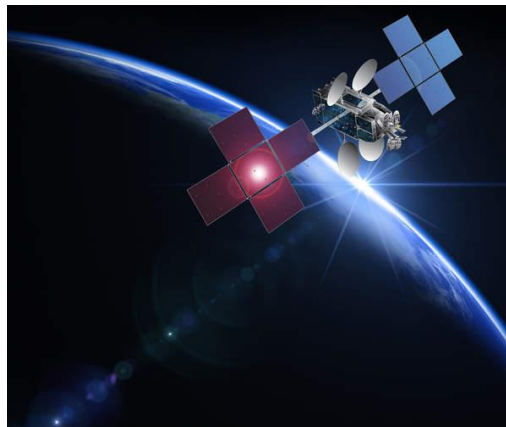


Figure 3. JUPITER 1

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<sup>4</sup> See *High-Speed Services for Internet Access: Status as of December 31, 2008*, at 7 (Feb. 2010), available at [https://apps.fcc.gov/edocs\\_public/attachmatch/DOC-296239A1.pdf](https://apps.fcc.gov/edocs_public/attachmatch/DOC-296239A1.pdf).

<sup>5</sup> In practice, the best DSL speeds widely offered today are 1.5 Mbps downstream, with upstream speeds varying between 64 and 640 Kbps. *Asymmetric DSL*, available at <http://computer.howstuffworks.com/dsl1.htm>.

<sup>6</sup> RSM-A (ETSI TS 102 188), *Satellite Earth Stations and Systems (SES); Regenerative Satellite Mesh – A (RSM-A) air interface*, available at <http://www.etsi.org/WebSite/homepage.aspx>, 2004.

<sup>7</sup> See *Sixth Broadband Deployment Report*, 25 FCC Rcd. 9556, ¶ 5 (2010) (establishing 4/1 Mbps broadband standard).



JUPITER 1 utilized technological improvements—the DVB-S2 standard based on LDPC error correction (invented by Hughes) and 16APSK modulation—to achieve aggregate satellite capacity of 120 Gbps, a twelvefold increase in capacity over the prior generation satellite, as customer demands for high-bandwidth downloads continued to increase. JUPITER 1 has reliably performed well beyond Hughes’ advertised broadband speed promises. In 2016, the FCC reported that Hughes provided its customers actual upload and download speeds of 195 and 152 percent of its advertised speeds.<sup>8</sup>

Recognizing the imperative to continue improving its service in order to meet market demand, Hughes once again moved quickly to address escalating requirements for capacity and speeds by designing a yet-more advanced satellite—JUPITER 2.

## **JUPITER 2: Delivering on the Promise of Broadband and Beyond to All**



*Figure 4. JUPITER 2 Launch, December 18, 2016*

With more than a three-fold increase in customers in the past ten years, Hughes launched JUPITER 2 in late 2016 and placed the satellite in commercial service in early 2017. This satellite, along with the rest of the Hughes satellite network, is bringing consumers broadband speeds of 25/3 Mbps and more, which once again meets or exceeds the Commission’s current definition of broadband.<sup>9</sup> This means that

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<sup>8</sup> See 2016 *Measuring Broadband America Fixed Broadband Report*, chart 4, available at <https://www.fcc.gov/reports-research/reports/measuring-broadband-america/measuring-fixed-broadband-report-2016>.

<sup>9</sup> See 2015 *Broadband Progress Report and Notice of Inquiry on Immediate Action to Accelerate Deployment*, 30 FCC Rcd. 1375, ¶ 3 (2015) (establishing 25/3 Mbps broadband standard).



U.S. consumers, even in the most rural and remote areas of the country, have access to high-quality broadband service at rates comparable to terrestrial broadband.

JUPITER 2 utilizes the recently developed DVB-S2X standard, which improves upon DVB-S2 by adding higher-order modulation schemes, smaller roll-off factors, and improved filtering. These and other features combine to permit more spot beams across the country to support more overall users. The satellite achieves a total of 220 Gbps capacity—nearly double JUPITER 1.

Customer demand has grown as service offerings have improved, and Hughes expects this trend to continue as more customers use JUPITER 2. Today, Hughes offers competitive consumer plans with a 50 GB/month data allowance and a speed guarantee of 25/3 Mbps for \$100/month, as well as an enterprise offering of 50/5 Mbps.

### Broadband Satellite Has Pushed the Technical Envelope

Hughes has exploited advances in efficiency of spectrum use, modulation, and multiple spot beam technology to grow its business and provide a better quality of experience to its customers. The innovations are illustrated in the following chart.

Years	Platform(s)	Highest Satellite Capacity	Max Number of Spot Beams per Satellite	Max Service Mbps (Downlink)
2006-2007	Prebroadband	1 Gbps	1 (traditional transponder)	1
2008-2011	SPACEWAY 3	10 Gbps	24	5
2012-2016	SPACEWAY 3 + JUPITER 1	120 Gbps	60	15
2017	SPACEWAY 3 + JUPITER 1 + JUPITER 2	220 Gbps	138	50

This chart illustrates, from the prebroadband era to 2016:

- A 4900 % growth in the maximum download speed service offering.
- More than a two orders of magnitude growth in satellite capacity.
- A transformation from the single footprint satellite era to the high-throughput, multiple spot beam era, with more than 5 times more spot beams used for JUPITER 2 than for SPACEWAY 3.

These enhancements in capacity and customer experience have been enabled by coding improvements (culminating in the use of the DVB-S2X standard) and the use of multiple spot beam transponders, permitting multiple uses of the full Ka-band spectrum in the satellite's coverage pattern. These innovations on the JUPITER 2 system provide additional capacity for broadband Ka-band satellite services to our customers in North America, added capacity in Mexico and certain Latin American countries, and to add capability for aeronautical, enterprise, and international broadband services.<sup>10</sup>

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<sup>10</sup> Hughes also recently launched a broadband satellite service in Brazil, and has additionally procured capacity on Telesat's new Telstar 19 Vantage satellite, scheduled for launch in the second quarter of 2018, to expand broadband satellite service in South America. See Press Release, "Hughes Launches Consumer Satellite





## The Future

Hughes continues to pursue improvements in coding and spectral efficiency, but it is reaching a point of diminishing returns with respect to the spectrum it currently uses. Consumer trends toward ever increasing download speeds and throughput capacity require all wireless broadband providers, whether terrestrial or satellite, to utilize more spectrum to meet these expectations. The capability of available spectrum on the Ka band is essentially at its limit, necessitating migration toward the Q/V bands. Satellite operators are currently designing their next-generation satellites to operate in these bands.

## Summary

The challenge for all of us is how to meet the growing demands of U.S. consumers for cost-effective, high-speed broadband connectivity no matter where they live or work. Satellite broadband is available today at broadband speeds recognized by the FCC to meet that call at rates comparable to terrestrial broadband services. For the approximately 34 million Americans in unserved and underserved areas,<sup>11</sup> it is unlikely that adequate terrestrial services will ever be deployed to meet their needs. However, satellite broadband has outperformed terrestrial in reaching these hard to reach areas on a timely and cost-effective basis. But in order for satellite providers to meet growing demands, they must have continued and increased access to critical resources, such as spectrum. Failure to ensure that this important resource is available to operators like Hughes would mean that the millions of Americans who live in the most rural and remote parts of the country would be deprived of the advanced services they need.

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Internet Service in Brazil," (June 29, 2016), *available at* <http://www.hughes.com/company/newsroom/press-releases/hughes-launches-consumer-satellite-internet-service-in-brazil>; Press Release, "Hughes and Telesat Sign Agreement for High-Throughput Capacity on Telesat's New Telstar 19 VANTAGE Satellite Covering South America" (Nov. 11, 2015), *available at* <http://echostar.com/NewsEvents/PressReleases/PressRelease.aspx?prid=31408>.

<sup>11</sup> As of the last available FCC report, 33,981,660 Americans lack access to Fixed Advanced Telecommunications Capability. 2016 Broadband Progress Report, FCC GN Docket 15-191, Appendix D, p.66, *available at* [https://apps.fcc.gov/edocs\\_public/attachmatch/FCC-16-6A1.pdf](https://apps.fcc.gov/edocs_public/attachmatch/FCC-16-6A1.pdf).